S P E C I F I C A T I O N

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that We George Edward MATICH, A British subject, residing at 52 Claydon Crescent, Basildon, Essex, Raymond John WALLS, A British subject, residing at 9 Manor Drive, Great Baddow, Chelmsford, Essex, and David Henry RAMSEY, A British subject, residing at 61 Manor Avenue, Pitsea, Essex, have invented certain and useful

RANGING SYSTEMS

24100-1

RANGING SYSTEMS

Background of The Invention

This invention relates to a continuous wave ranging system and, in one aspect, to an aircraft radar altimeter system.

Such systems usually comprise a means of microwave transmission upon which some form of coding has been added, and antenna for directing the energy to the target, an antenna for receiving the returned energy and, after amplification, a means of determining the amount of delay that has occurred on the signal, and hence the range of the target. The coding on the transmission had in the past been pulse or frequency modulation, but more recently phase modulation from a pseudo-random code has been used. This form of modulation has the property of producing a noise-like transmitted spectrum which is difficult to detect and hence finds applications where covertness is of importance. Covertness can be enhanced by reducing the transmitted power such that the returned signal is just sufficient for ranging measurement.

In such phase-modulated systems, the received

signal is correlated with a delayed version of the transmitted code, the delay being gradually increased in steps, and samples of the output of the correlator are detected and stored in an array. From this stored data, the delay, and hence the range, where the received signal return occurs can be found. A typical system is shown in Figure 1 and comprises:- a transmitter including an r.f. signal generator 1; a modulator 2 for modulating the r.f. signal in accordance with a pseudo-random code 3; a transmitter amplifier 4 and a transmitting antenna 5. The receiver includes a receiving antenna 6; a receiver amplifier 7; a correlator 8 for correlating the received signal with a delayed version of the transmitted code corresponding to the range being examined; an amplitude detector 10; and a memory array 11.

The data for such a system is shown in Figure 2, the code delay corresponding to range.

The system shown in Figure 3 uses the same reference numbers as in Figure 1 for corresponding portions of the system. The system shown in Figure 3 differs from that in Figure 1 in respect of the correlation system utilised. In this system, the

- 3 -

received signal is correlated with a selected phase
shift on delay 9 corresponding to the range being
tested. However, the system also includes a store 12
containing a plurality of different pseudo-random codes
and a selector 13 which supplies a suitable code from
the store 12 to the modulator 2 and the delay 9 and
hence to the correlator 8. The suitable code is
selected on the basis of the sidelobe characteristics to
be switchable for the range being tested and the
selector 12 and delay 9 are both controlled by a
controller 14.

In a direct sequence spread spectrum ranging
system, correlation sidelobes can appear at any range,
due either to the transmitter to receiver breakthrough
or to wanted signals. These sidelobe positions can be
shown to be related to the position of the signal
(breakthrough or otherwise) causing the sidelobe, and
the particular pseudo-random code sequence in use. By
careful selection of the code sequence, it is possible
to achieve a signal to sidelobe performance which allows
the sidelobes of wanted signals to be disregarded.
However, since the breakthrough signal is usually much
greater than any wanted signal, a problem is evident
when considering wanted signal to breakthrough sidelobe

- 4 -

levels. Since the breakthrough signal position is constant, it has been found possible for any given code sequence to determine the position of the resulting breakthrough sidelobes.

Summary of The Invention

Accordingly, the invention provides a continuous wave ranging system, comprising a modulator for modulating an r.f. carrier wave in accordance with a pseudo-random code, a transmitting antenna for radiating the modulated signal towards a target, a receiving antenna, an receiver for detecting the signal reflected back from the target, a correlator for correlating the reflected signal with the transmitted code with a selected phase shift corresponding to the current range gate to be tested, whereby the range of the target from the system may be determined, a store containing a plurality of different pseudo-random codes, and selector means arranged to supply to the modulator and to the correlator a code from the ~~store whose~~ *first a* sidelobe within ~~characteristics are suitable for~~ the next range gate or gates to be tested.

The pseudo random code used in the invention is preferably a maximal length code, *e.g.,* a sequence of numbers generated by a shift register with certain feedbacks on

it. For the system of the present invention, a code length of 2047 digits is preferred.

The present invention will ~~now~~ be described *below*, by way of example, with reference to the accompanying drawings, *to* ~~in which:-~~

Figure 3 is a schematic *block diagram* ~~view~~ of a system according to one embodiment of the present invention, ~~and~~

Figures 4 to 8 illustrate, in simplified diagrammatic form, plots of signals utilised in the system, *& Figure 3*

Figures 4, 5 and 6 show, in greatly simplified diagrammatic form, plots of signal level against examined range cell obtained by correlation for three different pseudo-random codes *A, B and C respectively*. The peaks marked with asterisks are the breakthrough sidelobes, while the peak marked (+) is the true signal. Since the position of the breakthrough sidelobes may be determined for any given pseudo random code in any given system, in one aspect of the invention, a range scanning algorithm is arrange to select the use of codes A, B and C to eliminate the effect of the breakthrough sidelobes.   The code is

changed only when necessary to minimise the effects of transients on changing code and the delay necessary to allow for the round trip time of the new code to the ground and back. In practice, the code is transmitted repeatedly, and for each sequence received, the code supplied for correlation is either maintained at the same delay for several sequences of code, to filter out the effect of any variations and thereby increase accuracy before stepping onto the next range gate, or the phase shift is incremented for each correlation.

Figure 7 shows in simplified form the sequence of codes selected to avoid the breakthrough sidelobes appearing in the diagrams of Figures 4, 5 and 6. Selection of code B avoids the first sidelobes appearing in Figures 4 and 6, while changing them to code C avoids the second sidelobe in Figure 4 ~~under~~ and the first sidelobe in Figure 5. Finally, changing to code A avoids the final sidelobes in Figures 5 and 6. The resultant response in idealised diagrammatic form is shown in Figure 7.

The code maps themselves are easily implemented by the use of arrays of Boolean variables indexed by range. Each Boolean entry need only signify the suitability of

a particular   code   for operation in the indexed   range.
In order   to   minimise the storage requirements for   the
resultant   code   maps,   it is desirable that   each   array
element in the map should cover a significant proportion
of the   entire range, for example 1/20th.   Thus each map
need only contain 20 values.

In   order   to minimise the number of   code   changes
made, the scanning algorithm will sometimes need to look
ahead   when faced with a choice of two or more   suitable
codes.   This look ahead will need to take into   account
the required   scanning order, but if an increasing range
scanner   is   used,   then the operation   merely   involves
looking   forward through the maps of each suitable   code
and choosing   the   one   which remains suitable   for   the
longest   range.   Should two or more codes satisfy   this
requirement, then the choice is unimportant.

o